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Elucidation of Aircraft Energy Use Through Time-Variant Exergy Analysis



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Abstract

Increases in fuel costs and environmental concerns have in recent years heightened the importance of fuel efficiency as a design consideration in vehicles, especially aircraft. For this reason, a greater understanding of the energy consumption of vehicles is needed, both for design and operational decisions. Exergy, a measure of available work in an imbalance of state, allows systems to be compared on an equal basis with losses and waste being equated to fuel costs. Vehicles and especially aircraft do not operate in steady state as do industrial plants, the traditional subject of exergy analysis. While some analysis of aircraft has been performed in the literature, time-variance has not been addressed, leading to a lack of detail and only very broad conclusions. It is proposed that in order to fully understand aircraft energy use, a fully time-variant analysis must be performed. It is the aim of this paper to discuss the first challenges encountered in designing a methodology to permit this and to describe the methods used to address these issues.

To perform time-variant exergy analysis, exergy data are gathered at regular time intervals over the course of a mission at the inputs and outputs of system components. Sufficient fidelity is only achieved when time intervals are short enough (e.g. around 1 second), leading to the requirement to store and analyze a large amount of data. A database structure and a graphical front-end have been designed for these tasks.

Intrinsic to the change from steady-state to time-variant exergy analysis is the inclusion of a storage term in

all control volume exergy balances. This change requires some alteration to the way in which calculations are performed, as well as leading to some proposed amendments to Grassmann diagrams. A simple electrically powered UAV is used to illustrate the methodology.

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Topic

- Energy consumption
- Energy conservation
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- Design processes
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